

X-547-64-108

NASA TM X-55044

GODDARD ORBIT INFORMATION SYSTEMS

BY

JOSEPH W. SIRY

N 64 28896

OTS PRICE

XEROX

\$ 2.60 ph.

MICROFILM

\$

FACILITY FORM 802

(ACCESSION NUMBER)

26

(PAGES)

TMX 55044

(NASA CR OR TMX OR AD NUMBER)

(THRU)

1

(CODE)

29

(CATEGORY)

JUNE 1964

NASA

GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

GODDARD
ORBIT INFORMATION
SYSTEMS

BY
JOSEPH W. SIRY

JUNE 1964

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

TABLE OF CONTENTS

	Page
I. Introduction	1
II. Space Elements	2
III. Time	6
IV. Orbit Numbers and Revolution Numbers	7
V. Equator Crossings and Related Types of Orbit Information	9
VI. Topocentric Coordinates	10
VII. Ephemerides	10
VIII. Viewing Predictions	11
IX. Acknowledgments	12

LIST OF TABLES

	Page
I. Space Elements	13
II. Descriptive Space Elements	14
III. Prediction Space Elements	15
IV. Osculating Space Elements	16
V. Julian Day for Space Numbers for 1964	17
VI. Julian Day for Space Numbers	19
VII. Equator Crossings	20
VIII. One Orbit Ephemeris	20
IX. SATOR Code	21

GODDARD ORBIT INFORMATION SYSTEMS

I. INTRODUCTION

Orbit information is issued by the Goddard Space Flight Center in a number of different forms. The Goddard Orbit Bulletin contains information giving the general characteristics of the orbit of the satellite of interest, as well as information in a form designed to be useful for certain prediction purposes. Topocentric coordinates are employed for the purpose of providing precise prediction information to a number of installations. Ephemeris information is furnished to those who utilize the spacecraft for scientific, technological, and other purposes. Viewing predictions for readily visible satellites such as Echo are provided for hundreds of cities around the world. Key features of the various types of orbital information furnished in these ways are described in the following sections. The discussion includes descriptions of systems of space elements and conventions concerning time and orbit and revolution numbers which are used in specifying the orbit information.

II. SPACE ELEMENTS

The first section of the Goddard Orbit Bulletin contains Space Elements which indicate mean characteristics of the orbit at the epoch. The Space Elements are listed in Table I. The section entitled "Descriptive Space Elements" contains various derived quantities, such as those shown in Table II, which are of interest to observers at the earth's surface. The section of the Bulletin which contains the Prediction Space Elements is provided for use in cases where approximate satellite positions are needed.

Values of the Prediction Space Elements are given for three or more epochs, t_i , $i = 1, 2, \dots, n$, in the manner indicated in Table III. The mean anomaly, $M(t)$, at a time of interest, t , in the interval between t_i and t_{i+1} can be obtained from the expression:

$$M(t) = M_i + \frac{C_1}{P_i} (t - t_i) - C_2 \frac{\dot{P}_i}{P_i^2} (t - t_i)^2, \quad (1)$$

where $C_1 = 518,400$, and $C_2 = 373.248$, when the angles are expressed in degrees, the time interval $(t - t_i)$ is expressed in days, the period, P_i , is expressed in minutes, and the period derivative, \dot{P}_i , is expressed in micro-days per day. In the case of each of the remaining five elements, a value corresponding to a time of interest in the interval between two Prediction Epochs can be obtained by interpolating, e.g., parabolically. An approximation to the satellite's position vector at a time of interest, t , can then be obtained by means of the following formulas or an equivalent set of expressions.

$$\underline{\Omega}(t) = \cos \Omega(t) \underline{i} + \sin \Omega(t) \underline{j} \quad . \quad (2)$$

$$\underline{\alpha}(t) = \cos i(t) \underline{k} + \left[\sin i(t) \right] \left[\underline{\Omega}(t) \times \underline{k} \right] \quad . \quad (3)$$

$$\underline{p}(t) = \cos \omega(t) \underline{\Omega}(t) + \left[\sin \omega(t) \right] \left[\underline{\alpha}(t) \times \underline{\Omega}(t) \right] \quad . \quad (4)$$

$$\underline{q}(t) = \underline{\alpha}(t) \times \underline{p}(t) \quad . \quad (5)$$

The eccentric anomaly, $E(t)$, is obtained in the usual way from Kepler's equation:

$$M(t) = E(t) - e(t) \sin E(t) \quad . \quad (6)$$

$$\underline{r}(t) = a(t) \left\{ \left[\cos E(t) - e(t) \right] \underline{p}(t) + \sqrt{1 - e^2(t)} \sin E(t) \underline{q}(t) \right\} \quad . \quad (7)$$

The formulas are referred to a right-handed, orthogonal coordinate system which is defined in terms of the planes on the true equator and the mean equinoctial colure associated with the epoch of the Space Elements. The x-axis is on the intersection of these two planes, directed toward the vernal equinox, the z-axis is directed along the earth's north polar axis, and the y-axis is an axis in the earth's equatorial plane, chosen so that the x-, y-, and z-axes form a right-handed, orthogonal set. Vector quantities are underlined. For example, the symbols i, j, and k denote unit vectors in the directions of the x, y, and z coordinate axes, respectively. The final formula gives an approximate expression for the satellite's position vector, r(t). The unit of length in this expression is the same as that of the semi-major axis, which is normally the earth's equatorial radius. The value of this radius associated with the Bulletin corresponds to the values for the semi-major axis which are given in the set of Space Elements in terms of the earth's equatorial radius and the decamegameter. This value can be employed by the entire receiving system, i.e., the system which uses the Prediction Space Elements. Alternatively, transformations of units can be made using the conversion factors of the receiving system.

The parabolas corresponding to the Prediction Space Elements given at the first three Prediction Epochs can be extrapolated through a limited interval to obtain elements corresponding to times earlier than the initial Prediction Epoch. In general, however, the accuracy associated with extrapolation is less than that associated with interpolation. Similar remarks apply to extrapolation to times beyond the final Prediction Epoch.

Osculating Space Elements are given in the manner indicated in Table IV. Their Cartesian equivalents are also listed. These are obtained using the given values of GM and the value of the earth's equatorial radius which was indicated above in the discussion of the Prediction Space Elements. If these values are not employed throughout the receiving system, it is usually preferable to enter this system with the Osculating Space Elements which are listed first in Table IV. These elements can be transformed into Cartesian quantities by means of equations (2) through (7) and the following formulas

$$a(t) = \left[C_3 P(t) \sqrt{GM} \right]^{2/3}, \quad (8)$$

and

$$\underline{v}(t) = \frac{C_4 a(t)}{P(t)} \left[\frac{\sqrt{1 - e^2(t)} \cos E(t) \underline{q}(t) - \sin E(t) \underline{p}(t)}{1 - e(t) \cos E(t)} \right], \quad (9)$$

or an equivalent set of expressions. In this case, t refers to the epoch of the Osculating Space Elements, and the quantity, $a(t)$, appearing in equations (7) and (9) is obtained from the relation (8). The value of GM used there is that which is employed in the receiving system. The units factors C_3 and C_4 can be chosen so that convenient quantities are obtained. For example, if P is in minutes, GM is in decamegameters³/centidays², and $C_3 = 1/C_4 = 1/28.8\pi$, then the semi-major axis, a , and the components of the vector, \underline{r} , will be expressed in decamegameters, and the components of the vector, \underline{v} , will be expressed in decamegameters/centiday.

III. TIME

For convenience, time is expressed in terms of the Julian Date for Space, or J.D.S., which is defined in terms of the astronomical Julian Date, J.D., as follows:

$$\text{J.D.S.} = \text{J.D.} - 2436,099.5 \quad . \quad (10)$$

The Julian Dates for Space are positive for epochs in the Space Age. The Julian Day for Space Number of a calendar day is defined simply as the Julian Date for Space corresponding to 0 hours, U.T., on that day. The last two digits of the Julian Day for Space Number of a given calendar day are identical with the last two digits of the Julian Day Number of the astronomical day beginning at Greenwich noon of the given calendar day. The Julian Dates for Space are convenient to use for these reasons and also because of their relatively small magnitudes. The Julian Day for Space Numbers for 1964 are given in Table V. Table VI contains Julian Day for Space Numbers corresponding to the first day of each month for the next several years, as well as for previous years beginning with 1958, the first full year of the Space Age. The Julian Day for Space Number for any day in this period can be obtained conveniently from the Table. The Julian Date for Space can be used directly in connection with the Prediction Space Elements. For example, quantities such as t and t_1 in expression (1) can be specified simply as the corresponding Julian Date for Space.

The symbol UT2W used in the Bulletin denotes UT2 time as broadcast by WWV.

IV. ORBIT NUMBERS AND REVOLUTION NUMBERS

In the Bulletin system, the portion of the orbit preceding the first ascending node is considered to belong to the first revolution, the portion of the orbit between the first and second ascending nodes is referred to as the second revolution, etc. The first ascending node can be associated with the first revolution, the second ascending node with the second revolution, etc.

If, in order to meet the mission objectives, an orbit is significantly changed one or more times, it is convenient to identify the different orbital arcs by numbering them. In such a case all major orbital segments are included in the numbering system. In the case of Syncom, for example, the Transfer Orbit is referred to as the first orbit, the next orbit, a nearly synchronous one, is referred to as the second orbit, etc. Each of the orbits is considered to begin at the end of a propulsion period, or at the time of a spacecraft separation or more generally at any time at which a new combination of spacecraft begins orbiting. In the case of an ordinary satellite, the Mission Orbit is often preceded by a Preseparation Orbit interval, extending from burnout to the spacecraft separation time. A Parking Orbit or a Transfer Orbit may also be employed. In such cases if there is a single, principal mission orbit, the various orbital arcs can usually be denoted adequately by the indicated terms. It is then not necessary to use an orbit numbering system.

The period is greater than a day for some high apogee orbits and lunar transfer orbits. It is sometimes convenient in such cases to further subdivide the orbital arc. A Lunar Transfer orbit, for example, can be divided into

one-day segments starting at its beginning. The first arc corresponds to the Near-Earth phase, the one or more intermediate arcs correspond to the Mid-course phase, and the final interval, usually shorter than a day, corresponds to the Lunar Approach phase. These arcs do not usually vary appreciably in character if the number of parking orbits changes. Other transfer orbits can be subdivided conveniently in similar fashion.

It is anticipated that it will usually be convenient to reckon revolutions of a lunar orbiter in terms of transits of the meridian at the selenographic longitude of 180° . Revolution numbers defined in terms of longitudinal transits will be referred to as longitudinal revolution numbers to distinguish them from the conventional revolution numbers which are defined in terms of ascending nodes. This distinction has practical significance, since longitudinal revolution periods are generally longer than nodal revolution periods. The portion of a lunar orbit preceding the first transit of the meridian at the selenographic longitude of 180° will be considered as part of the first longitudinal revolution, the period between the first and second transits of this meridian will be referred to as the second longitudinal revolution, etc. These longitudinal revolution numbers will often correspond directly to arcs of the lunar orbit which are visible from the earth.

For earth orbits, longitudinal revolution numbers based upon transits of the Greenwich meridian will be referred to simply as longitudinal revolution numbers or more briefly as long. revolution numbers. If necessary, to avoid ambiguity, they will be referred to as Greenwich longitudinal revolution numbers. For clarity, if longitudinal revolution numbers are defined in terms of

another meridian, the longitude can be indicated. For example, some of the missions associated with the manned spaceflight program begin and end near the meridian of Cape Kennedy. Accordingly, a revolution numbering system based upon transits of 80° West longitude has been used in connection with this particular program. The corresponding numbers can be referred to as 80° West longitudinal revolution numbers, or perhaps as Kennedy longitudinal revolution numbers.

Revolution numbers based upon nodal crossings are convenient to use in connection with most orbits and simplified orbit prediction systems which employ graphical and overlay methods. The longitudinal revolution numbers can be used if the entire orbital path can be printed readily on a world map.

Special cases can be handled within the framework developed above. For example, if necessary in the case of a nearly equatorial earth orbit, either the definition of a revolution can be based upon an appropriate period, or longitudinal revolution numbers can be used. Similarly, in the case of a nearly polar lunar orbit ordinary revolution numbers can be used if necessary.

V. EQUATOR CROSSINGS AND RELATED TYPES OF ORBIT INFORMATION

Orbital information is also provided in other forms in use including those found in portions of the Smithsonian Astrophysical Observatory and NORAD formats. The types of information supplied in the two sections entitled "Equator

Crossings" and "One Orbit Ephemeris" are indicated in Tables VII and VIII, respectively. The SATOR code appears in Table IX. The Modified Orbital Elements are equivalent to the quantities which are given in the SATOR code.

VI. TOPOCENTRIC COORDINATES

It has been found convenient in certain cases to provide precise station predictions by specifying the coordinates of the satellite in a local, topocentric Cartesian system. The directions of the coordinate axes in this system are toward the local east, north and vertical, respectively. The coordinates are specified at times separated by a regular interval, which is usually one minute in length. The satellite position vector components are expressed in decameters. The corresponding components at intermediate times are found by interpolation. The transformation is then made to any other quantities associated directly with the system in use at the station.

Predictions are also furnished in terms of other local coordinate systems. For example such quantities as range, range rate, azimuth and elevation are supplied at a time intervals which are chosen to satisfy the various requirements.

VII. EPHEMERIDES

Detailed information about the orbit is often furnished by giving listings of satellite positions at regular intervals. These ephemerides are usually supplied separately in the form of computer printouts and/or magnetic tapes. In the lists, time is referred to the Universal Time system and, in fact, is

usually based upon UT2W. Time is usually specified in terms of the calendar date, i.e., the year, month, day, hour, minute, and second. The positions are normally given at one minute intervals. The positions at intermediate times can be found by interpolation. A sixth order interpolation method is sufficiently accurate for almost every purpose. The satellite positions are usually referred to a world map coordinate system. Longitude and geodetic latitude are given in degrees and decimal fractions. Height above the ellipsoid is given in terms of a decimal fraction of a kilometer. Times when the satellite is not inside the earth's shadow are indicated by means of an asterisk following the height. An alternative version of the ephemeris contains values of certain parameters which characterize the earth's magnetic field and its radiation belt environment. This set of parameters includes quantities which specify the magnetic field vector and coordinates in B-L space. In the case of this particular form of the ephemeris, the experimenters' needs are met by furnishing geocentric latitude, and by specifying time in minutes and decimal fractions.

VIII. VIEWING PREDICTIONS

Viewing predictions are furnished for satellites, such as Echo, which are readily visible. These predictions, usually furnished separately in the form of computer printouts, are provided for a number of cities around the world. Prediction information is supplied for times at which the satellite is seen in a cardinal direction, i.e., when it is north, east, south or west of the city. The time and direction of view are given, together with the elevation angle above the horizon, and the direction of motion of the satellite.

All of the different types of information are not needed in every case. Individual issues may contain only appropriate portions of the entire Bulletin.

IX. ACKNOWLEDGMENTS

Valuable contributions in connection with the preparation of the Goddard Orbit Information Systems have been made by units of the Data Systems Division including the Advanced Orbital Programming Branch under Mr. T. P. Gorman, groups of the Operational Computing Branch under Messrs. B. Richardson and J. Kohout, and a group of the Theory and Analysis Office under Mr. D. Stewart.

TABLE I
SPACE ELEMENTS

Epoch: Calendar Date

Epoch: Julian Date for Space

Period, anomalistic	minutes
Period derivative	microdays/day
Eccentricity	
Inclination	degrees
Right ascension of ascending node	degrees
Right ascension of ascending node derivative	degrees/day
Argument of perigee	degrees
Argument of perigee derivative	degrees/day
Mean anomaly	degrees
Semi-major axis	earth radii, decamegameters

TABLE II
DESCRIPTIVE SPACE ELEMENTS

Epoch: Calendar Date

Epoch: Julian Date for Space

Period, nodal	minutes
Perigee height	kilometers, statute miles
Apogee height	kilometers, statute miles
Longitude of ascending node	degrees
Latitude of perigee	degrees
Velocity at perigee	kilometers/sec., st. miles/hour
Velocity at apogee	kilometers/sec., st. miles/hour

TABLE III
PREDICTION SPACE ELEMENTS

Epoch: Calendar Date

Epoch: Julian Date for Space

t_1 t_2 t_3

Period	minutes	P_1	P_2	P_3
Period derivative	microdays/day	\dot{P}_1	\dot{P}_2	\dot{P}_3
Eccentricity		e_1	e_2	e_3
Inclination	degrees	i_1	i_2	i_3
Right ascension of ascending node	degrees	Ω_1	Ω_2	Ω_3
Argument of perigee	degrees	ω_1	ω_2	ω_3
Mean anomaly	degrees	M_1	M_2	M_3
Semi-major axis	earth radii	a_1	a_2	a_3

TABLE IV
OSCULATING SPACE ELEMENTS

Epoch: Calendar Date

Epoch: Julian Date for Space

OSCULATING SPACE ELEMENTS

Period	minutes
Eccentricity	
Inclination	degrees
Right Ascension of Ascending Node	degrees
Argument of Perigee	degrees
Mean Anomaly	degrees

OSCULATING CARTESIAN QUANTITIES

X	decamegameters	earth radii
Y	decamegameters	earth radii
Z	decamegameters	earth radii
V_x	decamegameters/centiday	earth radii/canonical time unit
V_y	decamegameters/centiday	earth radii/canonical time unit
V_z	decamegameters/centiday	earth radii/canonical time unit
GM	$\text{decamegameters}^3/\text{centiday}^2$	$\text{earth radii}^3/\text{centiday}^2$

TABLE V
JULIAN DAY FOR SPACE NUMBERS
1964

January							February						
			1 2296	2 2297	3 2298	4 2299						1 2327	
5 2300	6 2301	7 2302	8 2303	9 2304	10 2305	11 2306	2 2328	3 2329	4 2330	5 2331	6 2332	7 2333	8 2334
12 2307	13 2308	14 2309	15 2310	16 2311	17 2312	18 2313	9 2335	10 2336	11 2337	12 2338	13 2339	14 2340	15 2341
19 2314	20 2315	21 2316	22 2317	23 2318	24 2319	25 2320	16 2342	17 2343	18 2344	19 2345	20 2346	21 2347	22 2348
26 2321	27 2322	28 2323	29 2324	30 2325	31 2326		23 2349	24 2350	25 2351	26 2352	27 2353	28 2354	29 2355
March							April						
1 2356	2 2357	3 2358	4 2359	5 2360	6 2361	7 2362				1 2387	2 2388	3 2389	4 2390
8 2363	9 2364	10 2365	11 2366	12 2367	13 2368	14 2369	5 2391	6 2392	7 2393	8 2394	9 2395	10 2396	11 2397
15 2370	16 2371	17 2372	18 2373	19 2374	20 2375	21 2376	12 2398	13 2399	14 2400	15 2401	16 2402	17 2403	18 2404
22 2377	23 2378	24 2379	25 2380	26 2381	27 2382	28 2383	19 2405	20 2406	21 2407	22 2408	23 2409	24 2410	25 2411
29 2384	30 2385	31 2386					26 2412	27 2413	28 2414	29 2415	30 2416		
May							June						
					1 2417	2 2418		1 2448	2 2449	3 2450	4 2451	5 2452	6 2453
3 2419	4 2420	5 2421	6 2422	7 2423	8 2424	9 2425	7 2454	8 2455	9 2456	10 2457	11 2458	12 2459	13 2460
10 2426	11 2427	12 2428	13 2429	14 2430	15 2431	16 2432	14 2461	15 2462	16 2463	17 2464	18 2465	19 2466	20 2467
17 2433	18 2434	19 2435	20 2436	21 2437	22 2438	23 2439	21 2468	22 2469	23 2470	24 2471	25 2472	26 2473	27 2474
24 2440	25 2441	26 2442	27 2443	28 2444	29 2445	30 2446	28 2475	29 2476	30 2477				
31 2447													

TABLE V
JULIAN DAY FOR SPACE NUMBERS

1964

July							August						
			1	2	3	4							1
			2478	2479	2480	2481							2509
5	6	7	8	9	10	11	2	3	4	5	6	7	8
2482	2483	2484	2485	2486	2487	2488	2510	2511	2512	2513	2514	2515	2516
12	13	14	15	16	17	18	9	10	11	12	13	14	15
2489	2490	2491	2492	2493	2494	2495	2517	2518	2519	2520	2521	2522	2523
19	20	21	22	23	24	25	16	17	18	19	20	21	22
2496	2497	2498	2499	2500	2501	2502	2524	2525	2526	2527	2528	2529	2530
26	27	28	29	30	31		23	24	25	26	27	28	29
2503	2504	2505	2506	2507	2508		2531	2532	2533	2534	2535	2536	2537
							30	31					
							2538	2539					
September							October						
			1	2	3	4					1	2	3
			2540	2541	2542	2543					2570	2571	2572
6	7	8	9	10	11	12	4	5	6	7	8	9	10
2545	2546	2547	2548	2549	2550	2551	2573	2574	2575	2576	2577	2578	2579
13	14	15	16	17	18	19	11	12	13	14	15	16	17
2552	2553	2554	2555	2556	2557	2558	2580	2581	2582	2583	2584	2585	2586
20	21	22	23	24	25	26	18	19	20	21	22	23	24
2559	2560	2561	2562	2563	2564	2565	2587	2588	2589	2590	2591	2592	2593
27	28	29	30				25	26	27	28	29	30	31
2566	2567	2568	2569				2594	2595	2596	2597	2598	2599	2600
November							December						
1	2	3	4	5	6	7	1	2	3	4	5		
2601	2602	2603	2604	2605	2606	2607	2631	2632	2633	2634	2635		
8	9	10	11	12	13	14	6	7	8	9	10	11	12
2608	2609	2610	2611	2612	2613	2614	2636	2637	2638	2639	2640	2641	2642
15	16	17	18	19	20	21	13	14	15	16	17	18	19
2615	2616	2617	2618	2619	2620	2621	2643	2644	2645	2646	2647	2648	2649
22	23	24	25	26	27	28	20	21	22	23	24	25	26
2622	2623	2624	2625	2626	2627	2628	2650	2651	2652	2653	2654	2655	2656
29	30						27	28	29	30	31		
2629	2630						2657	2658	2659	2660	2661		

TABLE VI
JULIAN DAY FOR SPACE NUMBERS

The Julian Day for Space Number given corresponds to the first day of the month indicated.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1958	105	136	164	195	225	256	286	317	348	378	409	439
1959	470	501	529	560	590	621	651	682	713	743	774	804
1960	835	866	895	926	956	987	1017	1048	1079	1109	1140	1170
1961	1201	1232	1260	1291	1321	1352	1382	1413	1444	1474	1505	1535
1962	1566	1597	1625	1656	1686	1717	1747	1778	1809	1839	1870	1900
1963	1931	1962	1990	2021	2051	2082	2112	2143	2174	2204	2235	2265
1964	2296	2327	2356	2387	2417	2448	2478	2509	2540	2570	2601	2631
1965	2662	2693	2721	2752	2782	2813	2843	2874	2905	2935	2966	2996
1966	3027	3058	3086	3117	3147	3178	3208	3239	3270	3300	3331	3361
1967	3392	3423	3451	3482	3512	3543	3573	3604	3635	3665	3696	3726
1968	3757	3788	3817	3848	3878	3909	3939	3970	4001	4031	4062	4092
1969	4123	4154	4182	4213	4243	4274	4304	4335	4366	4396	4427	4457
1970	4488	4519	4547	4578	4608	4639	4669	4700	4731	4761	4792	4822

TABLE VII
EQUATOR CROSSINGS

Northbound

EQUATOR CROSSING Northbound	TIME UT2W	LONGITUDE	HEIGHT
Number	Day Hour Minute	Degrees	Kilometers

TABLE VIII
ONE ORBIT EPHEMERIS
For Revolution Number

LATITUDE NORTH OR SOUTH	MINUTES PLUS	LONGITUDE CORRECTION	HEIGHT
Direction Degrees	Minutes	Degrees	Kilometers *

* Asterisk indicates satellite is not in earth's shadow

TABLE IX
THE SATOR CODE

SATOR	yylls	MDDHH	MMmmZ	IiiX	NOWES
LLLll	jKKkk	ARPER	WWWww	jnnnX	PERIOD
MMmmm	ppppp	ECCEN	eeeeee	PERRA	DDDDd
RAFRE	FFFff	RADEG	RRRrr		

The meanings of the symbols are as follows:

SATOR	Code indicator.
yylls	Spacecraft designator. yy denotes year of spacecraft launching. ll denotes the serial number of the launching in the set of launchings achieved that year. s denotes the number of the object in the set of objects orbited by that launching.
MDDHH	Month, day and hour of epoch of elements (M = 1 is equivalent to either January or November, etc.).
MMmmZ	Minutes and hundredths of minutes of epoch. Z denotes UT.
IiiX	Inclination, 0.01 degrees.
NOWES	Indicator for west longitude of ascending node at epoch.
LLLll	West longitude of ascending node, 0.01 degrees.
jKKkk	Prime sweep interval. j = 1 if PSI equals 1440 minutes plus KKkk; j = 2 if PSI equals 1440 minutes minus KKkk. $KKkk = (360) (1440) / (360.985648 - \dot{\Omega})$, where $\dot{\Omega}$ denotes derivative of right ascension of ascending node in degrees per day.

TABLE IX
THE SATOR CODE

ARPER	Argument of perigee indicator.
WWWww	Argument of perigee, 0.01 degrees.
jnnnX	Perigee derivative, 0.001 degrees per period, j = 1 denotes plus, j = 2 denotes minus.
PERIOD	Anomalistic period indicator.
MMmmm	Anomalistic period, 0.001 minutes. If MM is less than 85, 100 minutes should be added.
ppppp	Period derivative, 0.00001 minutes per period.
ECCEN	Eccentricity indicator.
eeeeee	Eccentricity, 0.00001.
PERRA	Perigee distance indicator.
DDDDd	Radial distance of perigee from center of earth, 0.1 statute miles.
RAFRE	Indicator for radiating frequencies which follow in five digit groups.
FFFFf	Radiating frequency, 0.01 megacycles.
RADEG	Right ascension of ascending node indicator.
RRRrr	Right ascension of ascending node, 0.01 degrees.